

Final Report for NASA grant NAG 5-3764
"Source Determination for Substorm-Related Ion Injections"
July 20th, 2001

The above referenced grant supported an effort to restore and analyze data from the Spacecraft Charging at High Altitude (SCATHA) spacecraft. This spacecraft, which was originally an Air Force mission, was launched into a near geo-synchronous orbit in early 1979 to investigate the inner magnetosphere at altitudes where it was known that spacecraft can undergo significant charging events. SCATHA included an ion composition experiment (designated SC8) and in many ways was a precursor to other missions, such as the AMPTE Charge Composition Explorer.

The ion composition data from SCATHA were stored on old 1600 BPI reel-to-reel magnetic tapes at the Lockheed-Martin Advanced Technology Center. These tapes, which were ~ 20 years old were rapidly becoming unreadable. At the same time, the software required to read the tapes, which was written to run on a VAX/VMS system, was in danger of becoming obsolete. Fortunately, R. J. Strangeway (the PI on this grant) had worked with the data in the early 1980's and had saved a copy of the original data reduction software. One of the primary tasks was therefore to retrieve as much of the data as possible from the old tapes, and also to resurrect the data reduction software.

Since data restoration in and of itself is not useful unless the data are of scientific impact, an equally important goal was to analyze the restored data, taking advantage of the orders of magnitude increase in computing power now available in comparison to the computational resources available in the early 1980's. Indeed in those days much of the analysis software, including methods for displaying the data, were largely hand-written. Furthermore, data storage was much more restricted. Now we can take advantage of analysis packages, such as IDL, and the ability to store entire data sets on-line.

Data Restoration Effort

Figure 1 shows one page of the web-based access to the 24-hour summary plots of restored SCATHA ion composition data. Data have been restored for February through September of 1979. For each 24-hour plot the gray-scale (color-coding on the web) indicates the fraction of the day for which data are available. In addition to the web-based access to summary plots, we have also restored the ascii files used to generate the summary plots, as well as the underlying binary data (converted to Unix binary), which can be used to generate other data products. At this time, the ascii and binary data are available on request.

The data restoration effort has ensured that the data will not be lost, since both the data files and the analysis and reduction routines have been transported to the Unix environment.

Furthermore, the ascii files can be easily ingested into other higher level programs, such as IDL. Indeed the ability to ingest the data into IDL has greatly expanded our capabilities in analyzing the data both as case-study analyses and within statistical studies.

Data Analysis Effort - Relationship between oxygen energy density and Dst

The ability to analyze the entire restored data set has been particularly useful in investigating the relationship between keV oxygen and proton fluxes and Dst. Dst, which measures the depression of the equatorial magnetic field at the Earth's surface, is often taken as a measure of the "symmetric ring current," that is the current associated with particles on closed drift paths around the Earth. In recent years several authors have argued that Dst also includes contributions from magnetopause currents, cross-tail currents, and even a "partial ring current." The exact nature of the partial ring current is not known, although again it has been argued that the partial ring current is carried by particles on open drift paths that come from the magnetotail to be lost through the magnetopause as they drift to the dayside. To make this distinction clear, a localized region of enhanced cross-tail current that closes through the ionosphere also constitutes a partial ring-current.

Figure 2 shows 16 days of SCATHA ion composition data acquired during a magnetic storm interval, as indicated by the minimum in Dst of about -140 nT. At the time of the Dst minimum a corresponding increase in energy density is observed for oxygen (the light gray trace in the third panel from the top of the figure). The energy spectrum (second panel) indicates that the enhancement in energy density is associated with increased fluxes in the ~ 10 keV energy range. Furthermore, most of these fluxes are carried by ions on open drift paths. The multiple m-shaped black trace marks the transition from closed gradient-drift dominated drift paths at higher energies to open drift paths at lower energies. This suggests that at least part of the Dst signature is associated with oxygen ions on open drift paths.

- It is also apparent from Figure 2 that the proton energy density in the SCATHA energy range (100 eV to 32 keV) is not a major contributor to variations in Dst, at least for this particular interval. This is also borne out statistically. Figure 3 shows the correlation between Dst and the energy density of oxygen ions and protons. The oxygen energy density has been mapped to a common L-shell, simply by assuming that the energy density varies as $1/L^3$. This L-shell dependence is not found for the protons, and so no equivalent mapping is performed. What is clear from the figure is that there is a significant correlation between the energy density of oxygen ions and Dst, as was seen in Figure 2. Since oxygen ions originally come from the ionosphere, this implies that the injection of ionospheric plasma is important for supplying the energetic plasma that results a depression of the terrestrial magnetic field, as measured by Dst. Furthermore, as indicated by Figure 2, an appreciable fraction of the oxygen ions are on open drift paths, and so are lost from the magnetosphere. This supports the suggestion that the more

rapid decay of Dst is associated with the loss of plasma through drift, rather than through charge-exchange or loss-cone precipitation.

As a follow on to the results presented here, we anticipate providing the SCATHA data to various modeling groups as a test-bed for their ring-current models.

Presentations and Publications

Strangeway, R. J., H. L. Collin, SCATHA observations of dispersing ion signatures in the inner magnetosphere, International Union of Geodesy and Geophysics, 22nd General Assembly, Birmingham, England, p. B.359, 1999.

Strangeway, R. J., Singly charged oxygen as a proxy for Dst, p. 178 (abstract), The First S-RAMP Conference, Sapporo, Japan, 2000.

Strangeway, R. J., and H. L. Collin, Evidence that ions on open drift paths contribute to Dst, *Eos, Trans. AGU*, 82(20), *Spring Meet. Suppl.*, Abstract SM41A-09, S357, 2001.

Strangeway, R. J., and H. L. Collin, Oxygen ions with energies below 32 keV as a proxy for Dst, in preparation, to be submitted to *J. Geophys. Res.*, 2001.

SCATHA Composition Data - Online PDF files

Legend

No Data

< 3 hour

< 23 hour

The color-coding in each table entry indicates the total amount of data plotted for the day.
Links to plots are disabled for days containing less than 1 hour of data.

1979

[Feb](#) [Mar](#) [Apr](#) [May](#) [Jun](#) [Jul](#) [Aug](#) [Sep](#)

February 1979

Su	Mo	Tu	We	Th	Fr	Sa
				1 (32)	2 (33)	3 (34)
4 (35)	5 (36)	6 (37)	7 (38)	8 (39)	9 (40)	
11 (42)	12 (43)	13 (44)	14 (45)	15 (46)	16 (47)	17 (48)
18 (49)	19 (50)	20 (51)	21 (52)	22 (53)	23 (54)	24 (55)
25 (56)	26 (57)	27 (58)	28 (59)			

March 1979

Su	Mo	Tu	We	Th	Fr	Sa
					2 (61)	3 (62)
	5 (64)	6 (65)	7 (66)	8 (67)	9 (68)	10 (69)
	12 (71)	13 (72)	14 (73)	15 (74)	16 (75)	17 (76)
18 (77)	19 (78)	20 (79)	21 (80)	22 (81)	23 (82)	24 (83)
25 (84)	26 (85)	27 (86)	28 (87)	29 (88)		

April 1979

Figure 1

SCATHA, Aug 23 - Sep 7, 1979

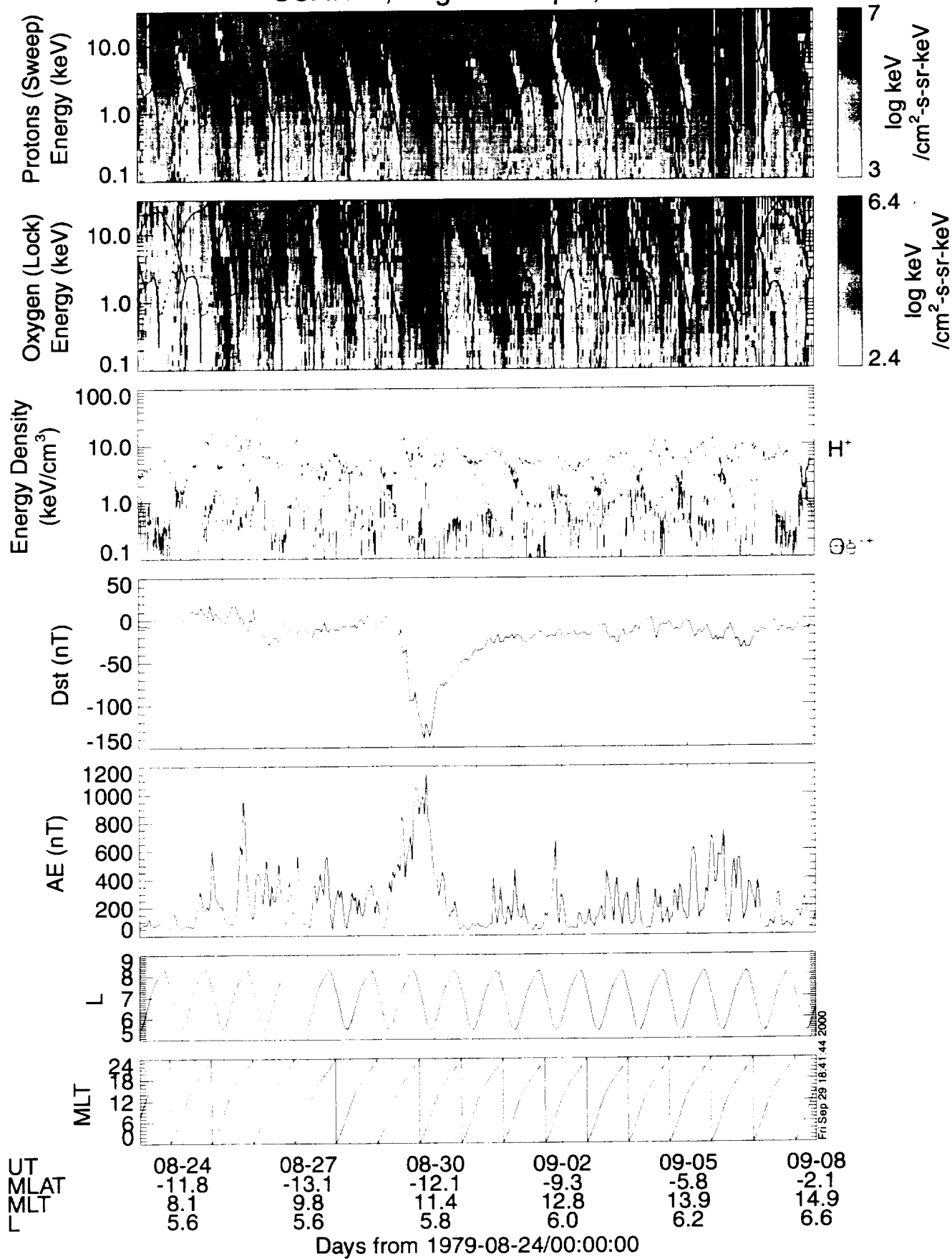


Figure 2

Energy Density - Dst Correlation

(Oxygen mapped to L=6)

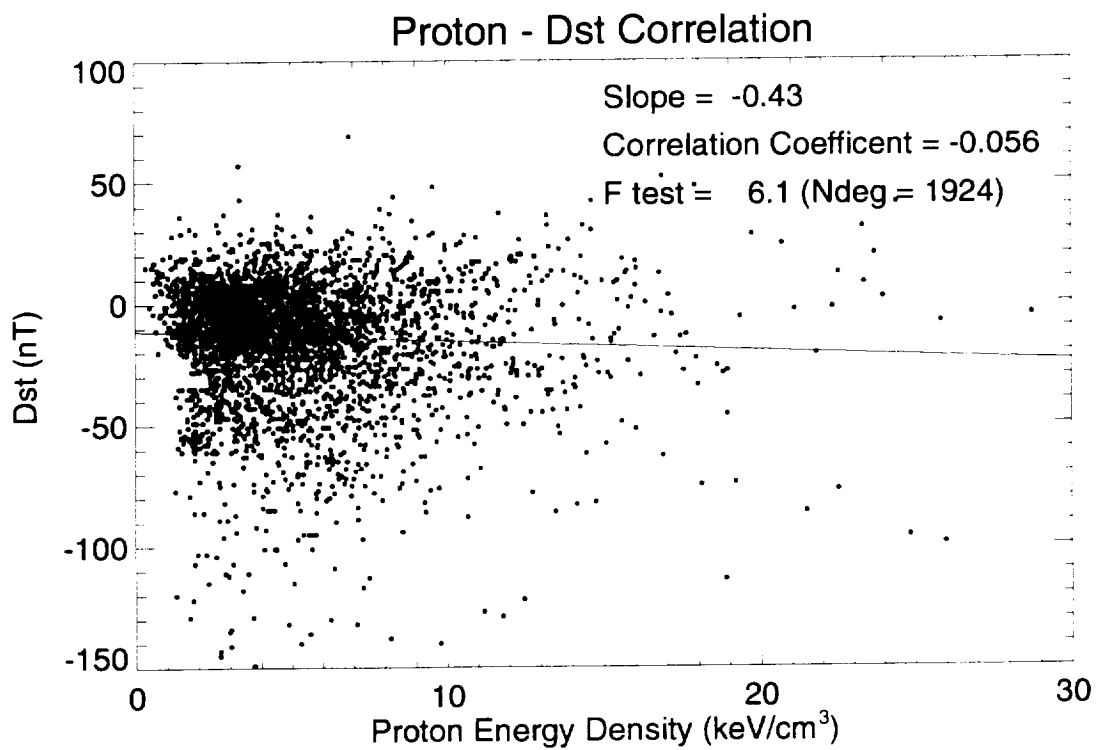
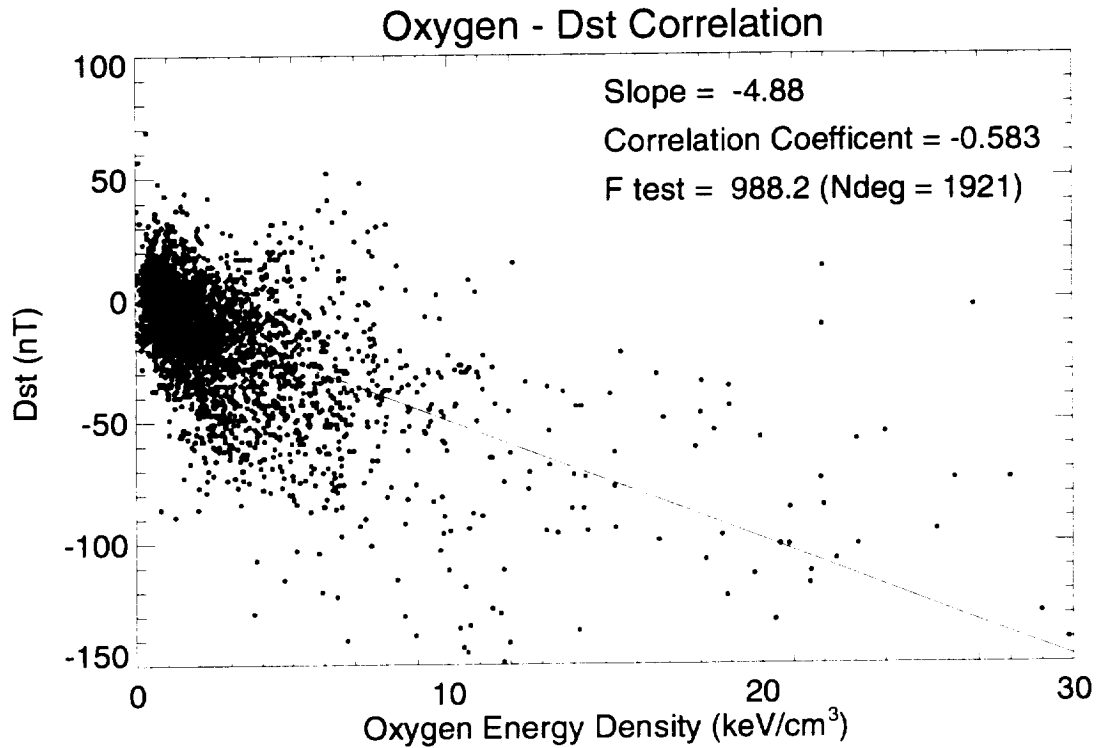


Figure 3